

Providing demining technology end-users need

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ABSTRACT

The paper starts with a description of the results of the EUDEM2 "Field Survey" carried out between March and June 2004 in a selected number of mine affected countries. This *Survey* addresses the need for information about technologies currently in use in the field for humanitarian demining and the personal opinions of field staff regarding both current and potential future technologies. The results include a list of field technologies, feedback from end users about them, deminers' statements of need ("wish lists") for new technologies, and expatriates' views of the particular situation of each country. Technology developers are thus provided with a systematic collection of basic information from the field, which can be used as a basis for proposing realistic and required solutions to the technology needs of landmine action. Additionally, field managers have information about technologies already used elsewhere which might be of use to their programmes.

The survey has been defined and supervised with the EUDEM2 project team (www.eudem.info), and has been carried out by the Department of Mechanics and Machine Design (DIMEC) of the University of Genova, in the person of the first author, in Mozambique, Namibia, Sri Lanka and Cambodia.

Finally the paper presents the research undertaken by the first author upon the results of the survey: the participatory design and development of a distributed system for area reduction.

Keywords: humanitarian demining technology, in-field survey, operational aspects of technology in use, end-users centered - sustainable technology, participatory design.

1. INTRODUCTION

There is a gap between the world of humanitarian demining technology researchers and the end-users.

Landmines are worst affecting the poorest countries: e.g. Angola, Cambodia, Afghanistan, Sri Lanka are among the most mine-afflicted countries in the world, while humanitarian demining technology researchers and producers are often based in rich countries, where the tools and money necessary to carry on research activities are available.

The places where technology is designed are usually far away both physically and culturally from the places where technology is used.

This gap results in a lack of communication between researchers and end-users.

We believe that the absence of communication is the main cause of the poor integration of new technologies in humanitarian demining operations in recent years, in spite of the fact that large resources, of the order of hundreds of millions of US\$ in the last 10 -15 years, has been spent on research¹[1].

¹ Prof. James Trevelyan of the University of Western Australia estimates total R&D funding for demining at about US\$300 million per year.

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2. IN-FIELD SURVEY

2.1. Survey Objectives

There's evidence of a lack of understanding of end-users realities, requirements and desires by demining technology developers. Speaking in terms of a humanitarian demining market, technology developers (sellers) have poorly investigated the world of technology users (buyers) and have not been able to propose too many attractive solutions.

There is an urgent need to develop new proper technology for humanitarian demining. In order to develop such technology, it is necessary to make correct assumptions. Before technology design can start, the "user market" must be analysed and operational constraints must be stated.

A recent study [2], carried out by the Government of Canada, defined the market for humanitarian demining equipment and technologies as a "non traditional market [...] as those who demand equipment and technology generally are not able to purchase it, the suppliers of the products have no marketplace in which to sell their goods, and the purchasers generally do not need or use the equipment themselves, but donate it to the demanders."

In response to these needs, the EUDEM2 project, with the support of the University of Genova, Italy, planned a survey of minefield technology and practice. The aim of this survey is to provide a first attempt to bridge the gap between users and manufacturers by making end users' needs available to manufacturers. This can be represented by an additional communication means in the simplified scheme of the humanitarian demining technology market shown below.

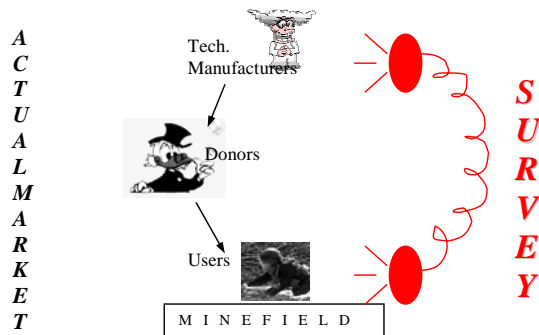


Fig. 1. Simplified scheme of humanitarian demining technology market and of role of the survey.

Technology developed by manufacturers, on the basis of the end users' needs, could be easier to introduce in demining practices, as users would have been involved in the whole design process, by having been asked to express their impressions about advantages and drawbacks of technologies in use and needs and requirements for new technologies.

Demining operations could eventually be accelerated and productivity increased.

Particularly, as the EUDEM2 international conference on humanitarian demining technology research held in September 2003 suggested [3], the survey addresses the need for a qualitative and quantitative analysis of the relatively few technologies that are actually used in the field, and specially the need for information about how deminers and demining organizations view these technologies. Moreover, it encompasses what end-users themselves consider their most urgent requirements.

2.2. Survey Methodology

The survey has been realized by visiting minefield sites and demining organizations, conducting interviews and analysing the collected data. The focus of the survey is technologies currently in use and their operational aspects, including application/use conditions, costs, and similar data.

We believe that the data reported in this survey will be useful for technology researchers and developers as well as for demining programme managers who want to know what technology has been used in certain countries and what end-users think about it.

For reasons of time and resources, the research was limited to four representative countries: Mozambique, Angola, Sri Lanka and Cambodia, and the collected information was mainly restricted to machine technologies.

The tools used to collect data were different according to the types of data and the stakeholders. Different stakeholders involved in the demining process, such as representatives of organizations, NGO's and mine action centres and local deminers employed by organizations, were interviewed.

A **survey toolbox**, including semi-structured interviews, questionnaires and group interviews, has been designed and used repeatedly in each organization visited.



Fig.2. Pictogram adopted to indicate semi-structured interviews.

A **semi-structured interview** with the representative of the organization was first done, at the beginning of the visit. The questions asked aimed at gaining a more comprehensive view of the landmine problem in the country, previously investigated in countries analyses. The representative's personal opinion on machine technologies in use by the organization, together with an evaluation of end-users skills, technology attitudes and capacities, was collected as well.

Finally, the representative was asked about the suitability of the questions included in the whole survey toolbox in order to be able to adapt or refine the methodology used.



Fig.3. Pictogram adopted to indicate questionnaires.

Information on the operational aspects of the technologies in use in the field has been acquired through open **questionnaires**. For every question only few possible answers were suggested, in order to address the people asked to the type of answer which was expected; suggested answers were short in order to allow the interviewer to record them easily and fast on paper. Questions were asked mainly to the logistical coordinator of the visited organization and only general comments such as advantages, drawbacks and possible improvements of the technologies in use, were asked also to deminers.

All questions included in the questionnaire were asked during personal face to face interviews.



Fig.4. Pictogram adopted to indicate group interviews.

Group interviews were used to gather data from deminers. During group interviews, participatory tools such as sorting and evaluation methods were used in order to exploit all the capabilities local people have already acquired and to allow them to use the same tools in the future, without outsiders' help, to understand, formulate and report their needs.

Group interviews with deminers were held after some days, once the relationship with local communities was established.

When time allowed, at the end of the survey, before leaving the organization, another in-depth interview was

held with the representative of the demining organization in order to review the first results.

2.3. Analysis and Organization of Survey Results

With the survey we aimed at providing technology manufacturers with a picture of different countries' technology scenarios, to better direct their efforts in designing new demining technologies suitable for the targeted end-users, related to region- or country-specific needs.

All data collected from the eight visited organizations have been analysed and presented in short schematic tables aimed at providing readers with easy, fast to read, comparable pictures of each single organization visited.

Tables relative to the organizations working in the same country have been merged in tables relative to the country to provide readers with comparable pictures of the countries visited, as well.

It is clear that attention must be paid when analysing and comparing data collected over different countries as there is no single mine problem and every situation is unique due to differences in the country's approach and type of region studied.

Maps, pictograms and colours have been used to help in a quicker and more intuitive reading of the document.

Maps have been used to locate where data comes from, pictograms to identify the type of tool of the survey toolbox used to collect the data.

Different colours have been used to underline results related to different countries. Within the same colour, different tones have been used to underline results related to different organizations.

Particular attention has been posed into the choice of colours to make the document, once downloaded from the Internet, suitable for printing and photocopying for easy distribution. The types of results corresponding to different data, tools and stakeholders are summarised in the table below.




Data	Tool	Stakeholder	Result
personal opinion on general landmine problem in the country	structured interview 	NGO representative	structured interview results for each organisation and for each country
operational aspects of technology in use	questionnaire 	logistics coordinator + deminers	questionnaire results for each organisation and for each country
user requirements for new technologies	group interview 	deminers	group interview results for each organisation and for each country

Fig.5. Table of types of Data, Tools, Stakeholders, Results

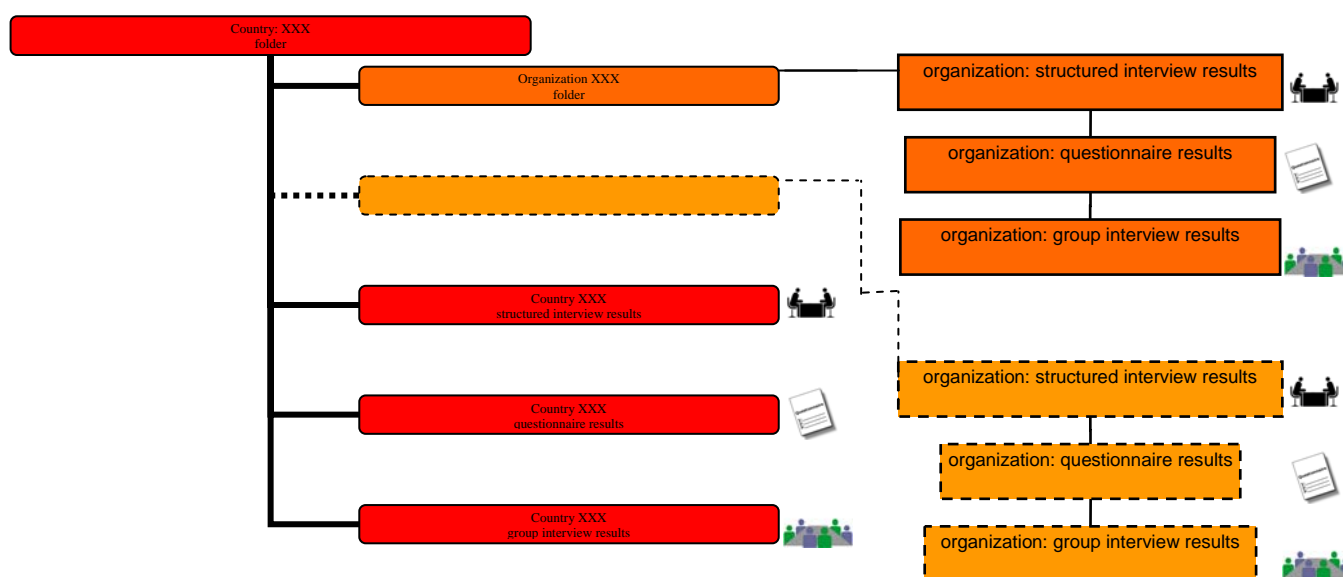


Fig.6. Organization of results related to the same country.

(E. E. Cepolina, C. Bruschini, K. De Bruyn, "Field Survey Results", EUDEM2 Technology Survey publication, 2005)

2.4. Summary of Survey Results

The survey allowed the team to establish good, even though, short relationships with end-users, by gathering information and opinions directly from them, especially during **group interviews**. End-users appeared to be really curious, open to communicating and expressing their opinions, as well as to learning new skills. Group interviews proved to be a very useful tool, both for the interviewers and for the group interviewed.

From the data collected on **technologies already in use**, it was found that the number of **mechanical technologies** employed by the organisations was limited to 1 or 2 items of equipment, used to support manual demining activities by preparing the ground. The one exception was MgM in Angola, who use nine different machines at different stages of demining operations. This shows that the strong interest in new technologies by senior management of this mine clearance organisation led them to rapidly introduce mechanisation to a far greater degree than is usual, and supports the conclusion that the barriers to new technology are not primarily technical but also organisational.

At the same time, the survey found a **strong general desire for new, small, light and cheap machines**, and it shows that there is a *unanimous opinion, held by organisation representatives, that deminers are willing to learn to use new technologies*.

End-users have in general appeared to *consider mini and medium flails as useful*, while representatives have expressed the desire to *have at their disposal earth processing and agricultural machines*, to employ them in humanitarian demining operations. A general requirement for machines is *to work in hot-humid weather and to last at least five years*.

Most of the **other technology** used by the organisations visited was *sensor technology, information & communication technology (ICT), as well as vehicles and power supply systems*.

- *Metal Detectors are the sensors used almost everywhere. Sri Lanka is in part an exception as two organisations employ rakes instead.* Different types of rakes are used for excavating soil, where minimum metal blast anti-personnel mines and no other mines or UXO are known to be found. The average calculated cost per year of operating a metal detector, including the cost of the operator and maintenance, was reported as three times more than the average yearly calculated cost in the case of a rake. The rakes used are standard low-cost commercial products which are adapted by fitting a longer handle. This is an example of how adaptation of commercial-off-the-shelf (COTS) equipment can, with only minor modifications, can fill a need for specialist demining tools, when local environmental conditions allow for its use.
- *ICT is mainly represented by GPS, two-way radios, satellite phones, digital cameras and laptop computers, as well as DGPS in one case (FSD in Sri Lanka).* These are mostly standard consumer electronics items and not the result of research and development of technologies for deminers.

- The types of *vehicles* used are pick-up trucks, large trucks, vans and motorbikes, whereas the types of power supply systems used are generators. Similarly, this is standard commercial equipment.

Technologies not specific to mine clearance clearly have an important role in improving the production of humanitarian demining. It might therefore be worthwhile to take a broader view of the technology needs of deminers and seek further technologies from other fields which can be directly used or adapted. Also, when discussing the lack of technology improvements for humanitarian demining it may be important to phrase the terms of reference to take note of the impact of this commercially available non-specialist support equipment, and discuss the technology needs in the context of items not otherwise available.

The calculated annual **cost** of all **sensors** used by an organisation, including maintenance and the human resources necessary to operate them, was reported as representing between one quarter and two thirds of that organisation's overall annual programme budget². The annual cost of all the **machines** was usually reported as being much lower than annual cost of all sensors employed by the same organisation. This difference is however partly due to *differences in the accounting procedures*, and the exclusion of costs by some organisations which have been included in the reporting of the others³.

3. DESIGNING DEMINING TECHNOLOGY END-USERS NEED

Results of the survey are not yet available on the Internet, as the verification of all data is quite time-consuming.

The first author is between the first person to use the results; on them, in fact, is based, the research initiated within the PhD course in mechanical engineering which has started in January 2005.

The PhD topic is the participatory design and development of a distributed system for area reduction in humanitarian demining. Given that every mine problem is unique and strictly linked to the area where it occurs, attention is focused on one particular region of one particular country: the north-eastern area of Sri Lanka.

Designing a technology for operating in a specific region helps concentrating efforts on a well defined problem; moreover, it allows involving local deminers in a project from which results they will benefit and allow to exploit the knowledge they have acquired in long years working in the field.

We have chosen Sri Lanka for several reasons: people are generally well educated, having typically attended 10 years of school, are enthusiastic, willing to work and learn new skills. Moreover, the country is facing an immediate post-conflict situation in which people are strongly involved in rebuilding the country. Furthermore, although the Tsunami disaster did not modify the landmine situation since the coastal areas were previously cleared, it heavily impacted

² This figure was not available for all cases.

³ The *Study* did not set out to investigate in detail the different cost analysis and accounting procedures of the organisations visited – the focus was on their opinions of technology for mine clearance, hence these financial results are reported without further analysis.

the local economy making even more urgent the need of providing cleared land to farmers.

We have chosen in particular to focus on the north-eastern region for it is where the NGO Norwegian People's Aid, which has agreed to collaborate in the study, is working. Therefore, the distributed system that will be designed will be conceived specifically to operate in the environment of this region, generally characterized by light vegetation and soft soil contaminated by small blast pressure-activated plastic mines.

The distributed system will be composed of several small, light and cheap machines, as generally required by the people interviewed during the survey. Machines will be designed from commercially off the shelf machines already available locally, specifically small agricultural machines such as power tillers. Once operations will be ended, or when not employed in demining activities, these agricultural machines could be properly used in agriculture. Machines will be adapted to perform ground preparation; a special end-effector will be designed to process the soil in front of the machine and bring mines up on the soil surface. Each machine could be remotely controlled to help a single deminer in his work by preparing ground in front of him, and all machines together could be controlled automatically to perform area reduction operations.

Machines will always be assisted by deminers: once a mine will be found and lifted up on the soil surface by the special end-effector, designed to suite the small agricultural machine, a deminer will come and remove the mine manually.

The latter has been introduced in order to lower machine complexity and cost as well as to allow a quicker integration of machines in operational procedures.

The whole system design process will be done in a participatory way together with deminers, in order to exploit all experience deminers have already acquired in years of field work, and to produce something close to their needs.

A one month trip to the north-east of Sri Lanka has been organised in January-February 2005. The trip was aimed at establishing contacts, deepen knowledge on the local environment and improving communication skills to make the participatory contribution more effective.

Collaboration with the Department of Mechanical Engineering of the University of Moratuwa, near Colombo, Sri Lanka, has been established. Collaboration with the international NGO Norwegian People's Aid (NPA), actively involved in humanitarian demining operations in the country since 2002, has been formalised, although already established during previous visits.

3.1. Overview of the work done up to May 2005

After the trip to Sri Lanka time has been spent to formalise the multiple inputs received in the field, from the definition of the environment of the north-eastern region of Sri Lanka to the organization of the ideas which came up during the interviews with local deminers, most notably on the functional requirements for a system of small, light and cheap machines working close to them.

Efforts went also towards the formulation of a philosophic/ethical frame of the thesis, reading and attending conferences and taking courses on development.

The idea at the basis of the thesis is, in fact, that technology plays an important role in favouring or not development, depending on the methodology technology is designed with. This is due to the strict link between development and dependency: the incapability of a country to cope alone with its problems slows development down.

The thesis aims therefore at proposing a new methodology for designing technologies to be used in developing countries. It suggests a participatory way to design technology, which makes use of and improves local knowledge. The design and development of a distributed system for area reduction in Sri Lanka is seen as case study for the application of this methodology.

Later, efforts have been concentrated on the organization and planning of the work. A system to design technology in a participatory way, termed *Snail System*, has been elaborated. The Snail System allows a progressive involvement of end-users in the design. Snails are lines connecting subsequent steps of the design process; snails develop along a straight line indicating time. Meetings with end users happen along the straight time line.

Every decision is taken together with end-users, only studies prior to decisions, such as the preparation of possible choices and simulations and calculations, are carried out by researchers and later presented to end-users. Each snail represents the work to be done to carry out a main package of the total work. The work flow is represented by a "snail" line as often it is iterative; the design process is repeated until a satisfying result is reached.

As meetings with end-users require time and money, especially if they foresee face to face interviews, two snails can be executed simultaneously, requiring different work behind meetings with end-users, but meeting of end-users at the same time. Graphically two snails can overlap.

The snail representing the first work package of the research is represented below.

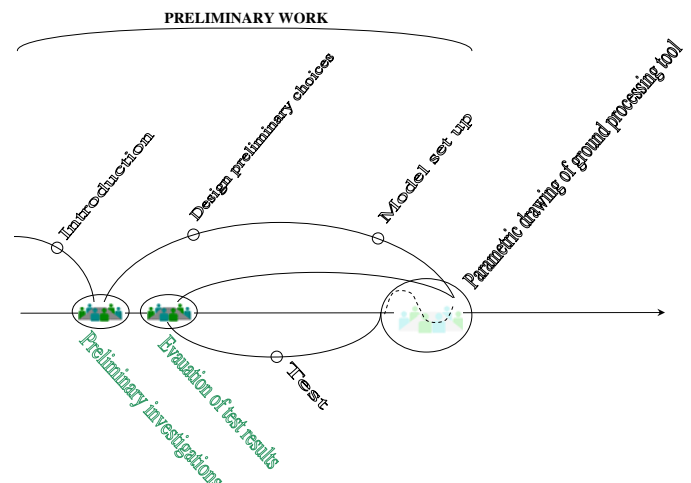


Fig.7. Snail representing the work flow of the first work package: Preliminary Work.

The preliminary work to the design process has started as well. After the *Introduction* and the *Preliminary Investigations* held in the field in Sri Lanka, the *Choices* preliminary to the design have been taken.

The market of small agricultural machines has been analysed, the type of machine to use has been chosen and the state of the art of existing end-effectors for ground processing has been started. At the same time, the principles of agricultural engineering at the basis of the design of earth processing tools have been studied and the proper design of a separate tool to be integrated to the end-effector to remove vegetation where it is necessary, has started with the help of another student of the University of Genova, Paolo Silingardi.

3.2. Future Developments

The proper design of the end-effector will start soon, once the Model will be set up.

In parallel with the work on the end-effector undergoing at the University of Genova, work on the remote control of the single machine is being done at the University of Moratuwa. Once, the end-effector will be designed, prototyped and tested on machines, sensors to make the machine able to understand when a mine has been lifted up, will be added. When machines will be able to work remotely, study on the system of machines working together at area reduction will start. Navigation algorithms will be developed with the help of the Swarm-Intelligent Systems (SWIS) research group of the EPFL. The human machine interface will be developed in a participatory way together with deminers.

4. SUMMARY

The EUDEM2 Field Survey shows that the application of technologies, in the organisations visited, is generally in the areas of sensors, information and communication technologies (ICT), transport and power supply systems. There is relatively little use of mechanical systems which directly assist the clearance process. Each organisation which was visited was using only one or two such systems, except for MgM which was employing nine different machines. These findings highlight the significant differences between the different mine clearance organisations surveyed. Another area where practices differ widely is in the calculation of the costs and financial benefits of technology. The research does also highlight a general desire for new, small, light and cheap machines, and it found that there is a unanimous and positive opinion about deminers' willingness to learn about and use new technologies.

Results of the survey will be soon available on the EUDEM2 Website (www.eudem.info). The EUDEM2 project is also happy to provide the complete results upon request?

The research undertaken by the first author within her PhD in mechanical engineering, started in January 2005 and is based on the results of the survey. The PhD topic is the participatory design and development of a distributed system for area reduction to be used in the north-eastern area of Sri Lanka. The work done until now, after the first visit to Sri Lanka held between January and February, and the work still to be done, are introduced.

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